Noninvasively Quantifying In Vivo Distal Femur Fracture Motion

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INTRODUCTION: Distal femur fractures have been associated with a particularly high rate of healing complications that has been at least partially attributed to detrimental biomechanical features of distal femur plate fixation. We sought to develop noninvasive methods of quantifying in vivo distal femur (AO/OTA 31-A,B,C) fracture motion via weightbearing CT (WBCT) to inform future research into mechanotransduction of fracture healing and surgical decision-making.

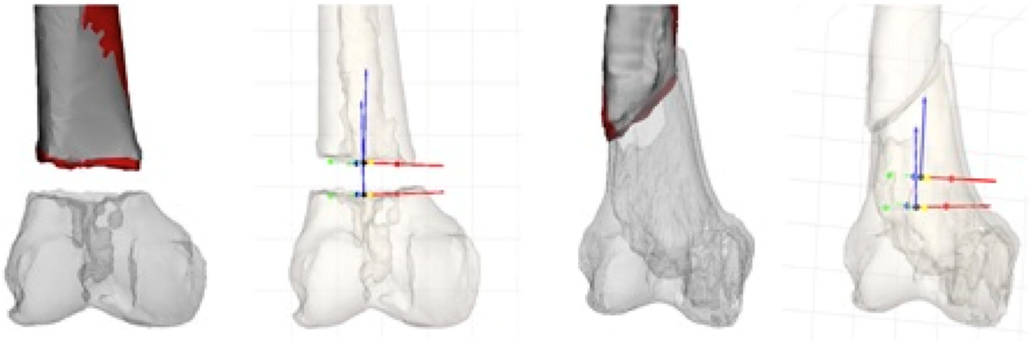
METHODS:

We employed bone-based tracking of non-WBCT and WBCT for seven osteotomized cadaveric specimens and four human subjects with distal femur fractures, including cases of intramedullary nailing and plate fixation. Bone segments from pre-fixation CT (devoid of metal artifact) were registered to post-fixation imaging. Motion was assessed via planes registered to proximal and distal bone segments (parallel within non-WBCT and tracked during WBCT).

RESULTS: Cadaveric data demonstrated the ability to detect differences in motion via WBCT, with mean shear and longitudinal motion differing significantly across specimens ($p<0.0001$) via linear regression of motion on specimens with covariates load and location within the osteotomy site. Figures 1A (cadaveric) and 1C (in vivo) overlay non-WBCT (gray) and WBCT (red) while Figures 1B and 1D demonstrate the position of the planes under load. Cadaveric testing (example in Figure 5A and B) demonstrated asymmetric motion through the osteotomy site with a similar pattern found in human subjects (example in Figure 5C and D). Cadaveric data demonstrated retrograde nailing resulted in motion similar to the more rigid plate fixation cases, and plate fixation was associated with highly variable magnitude and direction of motion. Among the 3 human subjects treated with plate fixation, average longitudinal motion medially was twice that laterally (2.2mm vs 0.9mm) under an average load of 168N. This suggests distal femur plate fixation is not more stiff than nailing, but results in much greater and more variable motion.

DISCUSSION AND CONCLUSION:

Our results support that lateral plating is not “too stiff”, but results in more variable and asymmetric motion than intramedullary nailing. The described method of in vivo motion assessment may allow for further objective assessment of motion for various clinical scenarios, and further exploration of the relationship between fracture site motion and later healing.



1A 1B 1C 1D

Figure 1: Cadaveric Results (Figure 1A and B) Mirrored by In Vivo Results in Human Subjects (Figure 1C and D).